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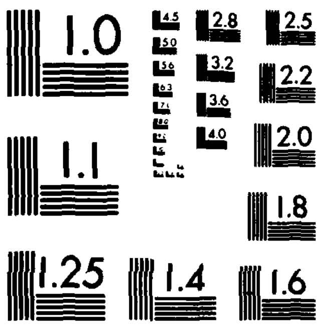

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U.S. ARMY TEST & EVALUATION COMMAND

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AD-A155 243

METHODOLOGY INVESTIGATION

FINAL REPORT

INTEROPERABILITY TEST METHODOLOGY

by

Richard G. Jacques

November 1984

US ARMY ELECTRONIC PROVING GROUND

FORT HUACHUCA, ARIZONA

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005-5055

2 MAY 1985

REPLY TO
ATTENTION OF

AMSTE-AD-M

SUBJECT: Methodology Report on Interoperability Test Methodology, TRMS No. 7-CO-PB4-EP1-003

Commander
U.S. Army Electronic Proving Ground
ATTN: STEEP-MT-DA
Fort Huachuca, AZ 85613-7110

1. Subject report is approved.

2. Test for the Best.

FOR THE COMMANDER:

GROVER H. SHELTON
C, Meth Imprv Div
Analysis Directorate

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The interoperability test methodology investigation was initiated to extend existing systems testing methodology to accomplish compatibility and interoperability testing of Army battlefield automated systems at the developmental test level. The current phase of the investigation resulted in the development of a test operations procedure for interoperability testing.

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FOREWORD

Ultrasystems Technology, Incorporated, Sierra Vista, Arizona assisted in the preparation of this document under Contract Number DAEA18-83-C-0003.

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1. SUMMARY

1.1 Background. The interoperability test methodology investigation was initiated to extend existing systems testing methodology to accomplish compatibility and interoperability (C&I) testing of Army Battlefield Automated Systems (BAS) at the Developmental Test (DT) level. The current phase of the investigation included the development of a Test Operations Procedure (TOP) for interoperability testing.

1.1.1 Problem. DoD has developed and is continuing to develop a number of major automated command, control, communications and intelligence (C^3I) systems. The critical element in the success or failure of these C^3I systems will be their interoperability and performance under load in a highly interactive tactical environment. To date, no automated comprehensive test capability or methodology exists which can fully evaluate the interoperability of these complex data handling systems, much less groups of these complex systems. Only independent segments of key performance parameters have been and can be evaluated with existing simulation and field type test facilities. This deficiency is due to the prohibitive cost of assembling all the interface hardware systems, troop elements, and environment generators essential to realistically reproduce realistically the loading conditions of a tactical environment. As a result, the Army is developing major systems with a critical role in the combat effectiveness of the Field Army without testing their ability to perform and interoperate under anticipated battlefield conditions.

1.1.2 Progress. Previous phases of this methodology investigation included the following activities:

a. Investigation of interoperability testing efforts at Army and other DoD facilities.

b. Development of a proposed test approach and measures of effectiveness (MOEs) suitable for interoperability testing.

These efforts are documented in the fiscal year final report, dated 28 October 1982.

1.2 Objective. The objective of this phase of the investigation was to adapt current methodologies to develop guidelines and procedures for test personnel to conduct C&I testing at the DT level.

1.3 Summary of Procedures. The methodology investigation analyzed the principles involved in C&I testing based on the findings of previous efforts and related projects. Use of the International Standards Organization (ISO) Open System Interconnect (OSI) network model was reevaluated and test instrumentation suitable for C&I testing was reviewed.

1.4 Summary of Results.

a. A test methodology was proposed which consists of an incremental test approach, a network model (ISO OSI), and MOEs patterned after the model. The structured, incremental approach provides an orderly method for testing potentially complex networks of interoperating systems and simulators/stimulators. Use of a network model is proposed as merely an aid in

identifying interoperability functions and as a convenient way of categorizing the MOEs and test parameters.

b. The test methodology requires test instrumentation capable of a distributed configuration of modular components for the stimulation and simulation of the interoperable network of systems. The Test Item Stimulator (TIS) possesses the test message database, real-time simulation, and data reduction and analysis capabilities required by the interoperability test methodology. Other instrumentation such as a hybrid monitor (HM) may provide measurement capabilities suitable for some aspects of C&I testing.

c. An interoperability TOP was produced to describe the procedures for performing C&I testing of systems.

1.5 Analysis.

a. The proposed test methodology specifies a systematic approach to interoperability testing. Such methods could increase the cost-effectiveness of testing by isolating problems to specific component system functions in an efficient manner.

b. TIS functional capabilities and its flexible configuration provided by a modular design, satisfy the majority of the instrumentation needs for interoperability testing. Further enhancements, such as integrating hardware/software monitors into the TIS, may be desirable as the methodology evolves with practical experience on tactical systems. Savings in interoperability test resources will result from substituting TISs for actual BAS in some test situations.

c. The interoperability TOP is a first attempt at defining interoperability test procedures at the DT level. Because the methodology is evolving, the procedures defined in the working draft will require refinement as they are applied.

1.6 Conclusions.

a. An approach to C&I testing has been proposed which would use test instrumentation currently being developed to provide cost-effective test procedures.

b. The interoperability TOP developed by this investigation provides a systems approach to C&I testing which will identify potential interoperability problems prior to system fielding.

1.7 Recommendations.

a. Functional decomposition of interoperability functions using a layered network model should be validated to determine its applicability to older communication schemes. Actual test experience should be used for refining and generalizing the network model and preliminary MOEs.

b. The interoperability TOP should be used for testing a tactical system. Evaluation and refinement of the procedures should be performed during this validation phase.

2.0 DETAILS OF INVESTIGATION. The definition of interoperability, C&I test responsibilities, the effect of current interoperability programs on U.S. Army Test and Evaluation Command (TECOM) activities, trends in development and testing of C^3I systems, and test approaches and MOEs used by various test agencies were examined in prior phases of the investigation. Results of prior phases were documented in the fiscal year final report, dated 28 October 1982. The final phase of the investigation focused on developing the test methodology using the TIS test instrumentation architecture and an interoperability model for identifying system under test (SUT) interoperability functions. A TOP for interoperability resulted from this effort.

2.1 Definition of Interoperability.

a. Interoperability, as applied to BAS, is the ability to exchange and process information between (among) systems. Information exchange is usually realized through the use of digital communication channels configured into a network. Processing of the exchanged information is performed through functions of the SUT which may be termed interoperability functions.

b. The interoperability test methodology is based upon function tracing throughout the network of interoperable systems. Interoperability functions perform processes which may be categorized as information (message) exchange with a database, SUT-specific functions, or an exchange of messages with another system. Interoperability of the network of systems is comprised of compatibility and system software interoperability issues.

2.2 Major Interoperability Programs.

a. High visibility of the C&I problem at all levels of the DOD has resulted in the creation of programs and assignment of responsibility to solve the problem. DoD Directive 5000.3 outlines Development Test and Evaluation (DT&E), specifically including C&I.

b. The Army Command and Control Master Plan (AC^2MP) describes a systems approach to manage interoperability efforts of BAS. The Center for System Engineering and Integration (CENSEI) has been assigned as System Engineer for technical execution of the ACCS and has developed an ACCS Systems Engineering Implementation Plan (SEIP). This plan describes the systems engineering functions required by the AC^2MP and the U.S. Army Training and Doctrine Command (TRADOC)-developed Army Battlefield Interface Concept (ABIC). Interoperability requirements of BAS not specifically addressed in the AC^2MP are provided by the ABIC. The test activity must address these directives and publications to define interoperability design and test functions.

c. The ACCS program extends beyond Army BAS to include coordination with joint-service and international programs. CENSEI has responsibilities in Joint Interoperability of Tactical Command and Control Systems (JINTACCS) and NATO programs to provide maximum flexibility for ACCS-developed systems. Existing standards in NATO and JINTACCS documents are used whenever possible to achieve this goal.

2.2.1 Army Command and Control System.

a. The ACCS program provides the systems approach required for comprehensive and effective C&I testing. Although the ACCS itself is under develop-

ment, progress to date has resulted in a well-organized approach to the system development process. The top-down management approach of the ACCS program is reflected in the hierarchical organization of the ACCS family of specifications. The top-level ACCS specification provides the technical definition of the overall ACCS. This document introduces the concept of functional and operational subsystems within the ACCS.

b. The functional area subsystem specification corresponds to the five functional areas (Intelligence/Electronic Warfare (EW), Fire Support, Maneuver Control, Air Defense, and Combat Service Support) of the TRADOC Command and Control Subordinate System (CCS2) architecture. (Communications comprises a sixth area in revised versions of the SEIP.) Specifications for operational subsystems correspond to the basic force elements of Army tactical forces. These include five division, seven separate brigade, and three echelon-above-division force elements.

c. The lowest level document is the Interface Specification (IS). The IS provides a detailed definition of requirements to be satisfied at a particular ACCS component system interface. The IS also describes the interface/interoperability standards for direct and indirect interfaces. Direct interfaces involve two directly coupled ACCS component systems while indirect interfaces imply an intervening component system(s). External interfaces to joint or international systems provide the link to JINTACCS and NATO. IS documents include physical, electrical, and information transfer characteristics of the interface.

d. The test philosophy proposed by ACCS includes C&I issues as a fundamental aspect of DT. C&I testing is considered a part of the normal life-cycle of a system with a long-term goal of interoperability as merely another aspect of testing.

2.2.2 Joint Interoperability of Tactical Command and Control Systems.

a. Joint Interoperability Test Force (JITF)-JINTACCS has provided procedures for conducting operational C&I testing. Although the JINTACCS program has concentrated on testing of message standards, the test plans and Technical Interface Design Plans (TIDP) are valuable references for C&I testers. While specifically oriented toward joint systems, much of the material is applicable to intraservice testing. The operational aspect of JINTACCS testing is appropriate to a study of interoperability at the DT level because of increased emphasis on combining DT/Operational Test (OT) as a means to conserve test resources.

b. JINTACCS also places component systems into five categories or functional segments, similar in nature to the ACCS grouping. This categorization aids in the management of the two programs and does not necessarily reflect a difference in methodologies required to test C&I issues among the various system types.

2.3 Interoperability Test Methodology.

a. The ACCS and JINTACCS approaches to C&I testing are valid for application to intraservice, joint, and NATO-level testing. The ACCS systems approach provides a hierarchy of specifications from total system to component systems and provides for external interfaces to satisfy JINTACCS and NATO

requirements. The definition of functional/operational subsystems of ACCS and JINTACCS is a management aid in the development of the total systems. C&I testing methodology has no inherent need for any particular classification scheme except where logistics or system-specific requirements exist.

b. The proposed methodology applies an incremental approach to C&I testing. The methodology uses a conceptual model of an interoperable BAS to aid in a functional decomposition of the SUT. A network model (ISO OSI) is used to establish hierarchical procedures and MOEs for C&I testing of the interfaces between C^3I systems. The structured assessment procedures minimize the test effort required to isolate interoperability problems to the failing subsystem component and, thus, eliminate expensive, and unnecessary, testing of higher level components until the performance of supporting lower level components has been verified.

2.3.1 Incremental Test Method.

a. As discussed above, the ACCS program provides a systems approach that can be applied to C&I testing. Implied in the ACCS approach, and specifically mentioned by the JITF, is the concept of an incremental test methodology. This involves the test of a component system to verify proper operation prior to interoperability testing. If this test is successful, further testing occurs with other interoperating systems added until the interoperability of the total system is assessed. A benefit of this approach is the ability to discriminate between communication and BAS malfunctions with minimum test resources.

b. The concepts mentioned above were refined into a test approach for interoperability. Test design should be performed with consideration for an incremental ("building block") approach. Scenario requirements should allow for single-thread testing to demonstrate proper operation of the SUT and interoperable systems or TISs in a stand-alone mode, verify the interfaces for compatibility, and ensure that test control and communication links are functioning properly. This phase should be followed by multi-thread testing of C&I issues. The SUT and test instrumentation configuration should follow a similar incremental approach with components colocated initially, evolving to a configuration using the fully extended SUT network for communication. Provision should be made for trial runs using a "quick-look" data reduction and analysis capability to establish performance baselines and to isolate problem areas as soon as practicable. The eventual SUT/test instrumentation configuration will consist of interconnected components (i.e., the SUT, available interoperable systems, TISs and other instrumentation) to form a multiple node test network based on existing and planned configurations of the SUT network.

2.3.2 Functional Model. The interoperability test method is based upon function tracing throughout the network of interoperable systems. To reduce the complexity of testing, compatibility issues were isolated from higher level interoperability functions. A conceptual model of interoperability processes was then formed to simplify (message) exchange with a database, SUT-specific functions, or an exchange of messages with another interoperating system. Further explanation of the functional model is provided in appendix D of the TOP. The interoperability test planning portion of the TOP describes the procedure for producing a functional requirements matrix based on interoperability processes of the SUT.

2.3.3 Network Model. The ISO OSI reference model was chosen as a basis for organizing test aspects of communications interfaces. The model (see figure 1) may be used to separate C&I processes as previously mentioned. Utility is also found in defining test instrumentation requirements, structuring tests (from lower to higher levels) for incremental testing, as an aid in identifying interoperability functions, and as a means of categorizing MOEs and test parameters. Details are provided in the previously referenced fiscal year report.

2.3.4 Measures of Effectiveness.

a. Preliminary MOEs were proposed in an earlier phase of the investigation. For purposes of DT level interoperability testing, MOE and measure of performance (MOP) are considered synonymous.

b. The layered network model can provide the foundation for the test criteria and parameters that pertain to interoperability issues. The interface that is being tested can be subdivided into the seven, more manageable layers (or levels) of the ISO OSI model. Test parameters may then be identified for each level of the interface and combined to produce a hierarchy of MOEs.

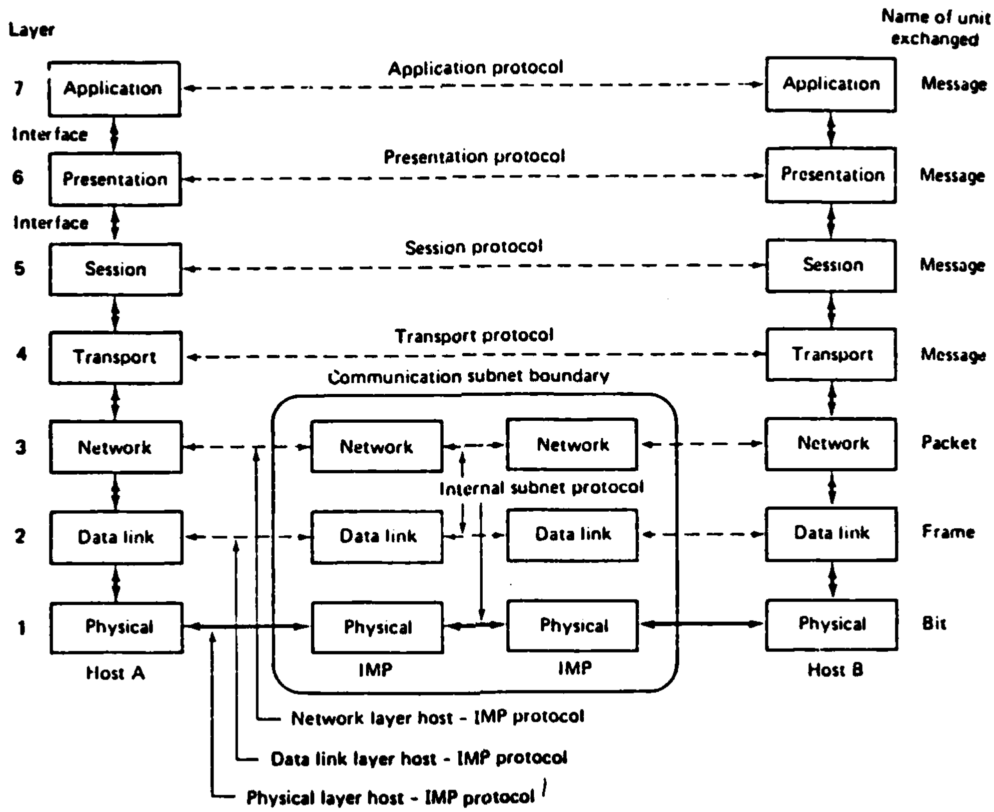
c. Some MOEs associated with the lower layers (compatibility issues) of an interface are dependent upon the physical channel characteristics, while MOEs for higher layers reflect SUT-specific functions. Structured design techniques being used on newer systems (e.g., Position Location Reporting System (PLRS)/Joint Tactical Information Distribution System (JTIDS) Hybrid (PJH) use of X.25 protocol) may allow generic MOEs to be developed in the future.

2.4 Interoperability Test Instrumentation.

a. Existing methodologies and test instrumentation used for single system testing were reevaluated in terms of interoperability test demands. This process produced the requirements for test instrumentation that provides for flexible configuration and compatibility with existing and planned tactical systems. A separate project evolved from this effort and is currently developing the TIS to satisfy these initial interoperability instrumentation requirements.

b. Other test drivers, similar conceptually to TIS, were examined as well as other instrumentation which would enhance the measurement capability for interoperability testing. This instrumentation is briefly described below.

2.4.1 Test Item Stimulator. The Interim Test Item Stimulator (ITIS) was a test driver which was developed by the U.S. Army Electronic Proving Ground (USAEPG) for DT of the Maneuver Control System (MCS). The ITIS proved useful for single-system testing with prescripted message streams. Interoperability testing, by definition, requires the ability to simultaneously test multiple systems and allow for the real-time generation and insertion of messages into test message streams. Thus, the ITIS has evolved into the TIS to meet these additional test requirements. Test conduct using the TIS is separated functionally into three phases: pre-test scenario preparation, real-time item



LAYER	TITLE	DESCRIPTION
1	Physical Layer	Physical connections necessary to transmit data on a bit I/O level
2	Data Link Layer	Transforms raw bits into error-free line to network layer
3	Network Layer	Groups data into packets, routes packets to destination, performs error accounting
4	Transport Layer	Accepts data from session layer, forwards to network layer, assures end-to-end accountability
5	Session Layer	User interface to network, handles connection establishment
6	Presentation Layer	Library of common application functions shared among users
7	Application Layer	Unique messages handling specific to application

Figure 7. ISO OSI Seven-Layered Model

stimulator, and post-test data reduction and analysis. The TIS design is described in more detail in appendix C.

2.4.2 Air Force Simulation, Monitoring, Analysis, Reduction, and Test System. Test instrumentation to complement the procedures of JINTACCS is being developed by the Air Force Simulation, Monitoring, Analysis, Reduction, and Test System (SMARTS). The proposed SMARTS would automate many of the processes currently performed manually. Like the JITF, SMARTS allows centralized control of decentralized test facilities, independent testing by the decentralized test facilities, and flexible test configuration and will have the capability to support intraservice, joint, and NATO-level testing.

2.4.3 Hybrid Monitor.

a. The HM concept (an integration of both hardware and software monitors into a central monitor system) evolved from earlier investigations of standalone hardware and software monitors. The concept of integrating the capabilities of both hardware and software monitors controlled by a central monitor - the HM approach - was developed in an attempt to exploit the desirable features of both monitors while minimizing their shortcomings.

b. The multiprocessor hybrid performance monitor potentially has several advantages over hardware or software monitors. It is able to monitor a network of processors simultaneously. The hybrid should also prove to be easily reconfigurable and allow the tester to approach collection of data using several methods which blend the degree of hardware and software monitoring required for a particular system.

2.5 Technological and Economic Constraints.

a. The nature of interoperability necessitates the involvement of multiple systems. The number of systems involved forms the basis for technical and economic concerns of considerable magnitude. Technical problems for C&I testing parallel those encountered in developing the sophisticated C^3I systems themselves. The high data rates and large volume of data exchange place large demands on the measurement system architecture and data reduction and analysis capabilities. Limited resources often prevent the assembly of the necessary interoperating systems and personnel and place even greater technical demands on the test activity. Development of stimulators/simulators, such as the TIS, is a cost-effective way to minimize the actual tactical system equipments required during interoperability testing.

b. The large volumes of data inherent in interoperability testing may be reduced through the use of special techniques such as exception reporting and statistical data recording, or recording only samples of the raw data. Test instrumentation must possess automated data reduction and analysis capabilities to allow effective analysis of the test data.

c. The effect of limited economic resources upon comprehensive C&I testing may be reduced by combining DT/OT tests--combined DT/OT should use common test issues, the same instrumentation, and the same philosophy of following a scenario script whenever practicable. The ACCS program endorses such testing to conserve test resources.

2.6 Interoperability Test Operations Procedure. An interoperability TOP was developed to describe the facilities, instrumentation, preparation for tests, test categories, test planning, test controls, test methods, data reduction and presentation methods.

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APPENDIX A

METHODOLOGY INVESTIGATION PROPOSAL

EXHIBIT P-16 (Part I) Date: 1983
Production Engineering Measure (PEM) Project
RCS DRCMT-835

SUBTASK No. 67

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1. Project Number: 0855071 (TECOM) 2. Fiscal Code: PA 5397 3. Cost: $100K

4. Project Title: Interoperability Test Methodology

5. Name and location of facility/contractor: US Army Electronic Proving Ground, Fort Huachuca, AZ 85613

6. General Objective: Reduced costs; increase efficiency.

7. Problem: Only independent segments of key performance parameters have been and can be evaluated with existing simulation and field test facilities. The deficiency is due to prohibitive costs of assembling all the interfacing hardware systems, troop elements, and environment generators essential to realistically reproduce the loading conditions of a tactical environment. As a result, the Army will produce major systems with a critical role in the combat effectiveness of the Field Army without adequately testing their ability to perform and interoperate under anticipated battlefield conditions. Current methodologies must be upgraded to fully evaluate the interoperability of production automated systems.

8. Proposed Solution: Automate state-of-the-art methodologies and establish appropriate simulations, including computer simulations and physical simulators; or drivers to simulate interactive interoperants interfacing with the test systems. General purpose concepts will be emphasized to make the capability applicable to the broad spectrum of modern battlefield electronic systems which will require performance validation during production testing.

9. Justification: If this task is not accomplished, it will be infeasible to conduct adequate interoperability testing on a broad spectrum of major, electronically based, computer driven materiel systems. As a result, there will be a significant lack of assurance that these systems will interoperate with the many other interoperants on the battlefield. The risk accompanying such a situation would be intolerably high.

10. Benefits:

a. Quantifiable benefits (S/I): None Basis:

b. Non-quantifiable benefits: Dollar savings cannot be quantified since there is no economically feasible alternative which would accomplish the requirement for interoperability validation.

11. Deliverables: A description of the techniques employed, the results, specifications, limitations of the defined production test capability and other pertinent information will be documented in a final report at the conclusion of this effort.

12. Funding Profile and Scheduled Technical Completion Dates:

Fiscal Year	$Costs, (XK)	Month-Year
FY 85	$100K	Sep 85
FY 86	$100K	Sep 86
FY ___		
TOTAL		

13. End Items Supported: The following generic types of production systems will be supported.

a. Primary - Intelligence Systems; Electronic Warfare Systems; Command and Control Systems and Communications/Navigation Systems
b. Secondary - N/A.

14. Key Milestone Dates:

a. PEP Completion for primary end item - N/A
b. MMT Completion - September 1986
c. Primary End Item TC - N/A
d. Start of Full Scale Production - N/A
e. Preliminary Design Criteria for Facility - N/A

15. Related MMT and Feasibility Demonstration Efforts:

a. Project Nos.	67	___	___	___
b. Initiation Date	Jan 80	___	___	___
c. Completion Date	Sep 85	___	___	___

16. Plan for Implementation of Efforts' Results:

a. When - FY85/86
b. Where - US Army Electronic Proving Ground
c. How - Procure the required test equipment and facilities.
d. Who - TECOM activities responsible for interoperability testing of automated systems.
e. Cost - Cost of implementation will be dependent upon the required equipment/facilities defined by this task, and thus cannot be quantified at this time.

17. Energy Resource Impact Statement: Study does not require resources beyond those required for study, analysis, and computer program generation; therefore, no impact is expected on energy resources.

Project Engineer:

a. Name - Larry W. Miller
b. Organization - Cdr, US Army Test & Evaluation Command, ATTN: AMSTE-AD-M, APG, MD 21005-5055
c. Phone Numbers, AUTOVON 283-3677 Commercial 301-278-3677

Enclosure 1 - Environmental Documentation
None required.

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APPENDIX B

ACRONYMS

ABIC .... Army Battlefield Interface Concept

ACCS .... Army Command and Control Systems

AC^{2}MP .... US Army Command and Control Master Plan

BAS .... Battlefield Automated Systems

CCS .... Communications Control System (Advanced Field Artillery Tactical Data Systems)

CCS^2 .... Command and Control Subordinate System

CENSEI .... Center for System Engineering and Integration

C&I .... Compatibility and Interoperability

C^{3}I .... Command, Control, Communications, and Intelligence

CTP .... Coordinated Test Plans

DBMS .... Data Base Management System

DT .... Developmental Test

DT&E .... Developmental Test and Evaluation

EDC .... Error Detection and Correction

EFL .... Event Format Library

EPUU .... Enhanced PLRS User Unit

EW .... Electronic Warfare

HIU .... Host Interface Unit

HM .... Hybrid Monitor

IS .... Interface Specification

ISO .... International Standards Organization

ITIS .... Interim Test Item Stimulator

JINTACCS ..... Joint Interoperability of Tactical Command and Control Systems

JITF .... Joint Interoperability Test Force

JTIDS .... Joint Tactical Information Distribution System

MCS .... Maneuver Control System

MFL .... Message Format Library

MOE .... Measure of Effectiveness

MOP .... Measure of Performance

OSI .... Open System Interconnect

OT .... Operational Test

PEM .... Production Engineers Measure

PLRS .... Position Location Reporting System

PJH .... PLRS/JTIDS Hybrid

SEIP .... Systems Engineering Implementation Plan

SMARTS .... Air Force Simulation, Monitoring, Analysis, Reduction, and Test System

SSA .... System-Specific Applique

SUT .... System Under Test

TCT .... Tactical Computer Terminal

TDC .... Time Dispersal Coding

TECOM .... U.S. Army and Evaluation Command

TIDP .... Technical Interface Design Plans

TIS .... Test Item Stimulator

TOP .... Test Operations Procedure

TRADOC .... U.S. Army Training and Doctrine Command

URO .... User Read-Out

USAEPG .... U.S. Army Electronic Proving Ground

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APPENDIX C

TEST ITEM STIMULATOR

1. Test Item Stimulator.

a. The TIS has evolved from the ITIS in order to meet the additional requirements of interoperability testing. The TIS was designed to provide the capability to generate message traffic to support the testing of C^3I systems including:

. JTIDS class 2 terminal using TADIL-J messages.

. TSQ-73 host interface unit (HIU) using ATDL-1 and TADIL-B messages.

. Hawk HIU using ATDL-1 messages.

. Tactical computer terminal (TCT) HIU using MCS messages.

. TACFIRE Communications Control System (CCS) using TACFIRE CCS messages.

. PJH enhanced PLRS using unit (EPUU) using user read-out (URO) message and EPUU messages.

b. The pre-test, real-time, and post-test functions run on the same VAX 11-based system. As a result, all three phases have access to the test message database. The pre-test software provides the interactive capability to specify test conditions and maintain a library of message formats (MFL), and generate scenario events. Scenario messages are organized into events which, together with the underlying format definitions, comprise the Event Format Library (EFL). The real-time software generates, monitors, and records message traffic during the tests, providing for the interactive control of the test environment and parameters. The design also includes the capability for real-time operator-oriented event generation. The post-test software processes test data for test report generation.

2. Pre-Test. The pre-test function supports on-line generation, review, and modification of test scenarios. The test scenarios consist of time-sequenced events and test actions which change the value of a system simulation parameter, provide test control information, or trigger required responses. Two types of events occur in scenarios:

a. Prescripted events - generated from pre-test operator-entered messages and directly transmitted to the SUT during real-time processing.

b. Real-time events - generated from pre-test operator-entered events that are manipulated during real-time testing to generate messages for transmission to the SUT.

3. Real-Time.

a. The real-time function provides the interface for stimulating and monitoring the SUT. The real-time function processes both scenario and operator-entered messages, producing a message stream to stimulate the SUT. The resulting message exchange is logged for later processing. The protocol

handlers, formatters, and interface elements dealing with a specific protocol are collectively referred to as a system-specific applique (SSA).

b. Scenario-based and operator-entered messages driving the real-time processing are scheduled through the event reader. Command messages are routed to the SSA control process, where they modify the test execution. Pre-scripted messages are sent directly to the transmit process, which transmits data to the SUT and logs the transmission. Real-time messages and response messages are routed to the real-time message generation and response handling processes, which in turn, send transmittable messages to the transmit process. The receive process logs the SUT messages received and sends the received data to the response handling task, possibly triggering a response. Test notes are displayed to the operator and routed to the logging process.

4. Post-Test. Post-test processing of the log files generated during testing produces statistical reports on message content and end-to-end system throughput.

5. Test Configuration Data.

a. The TIS is designed to operate in a network configuration with other TISs during a test.

b. Each TIS consists of four SSAs which are driven by separate scenarios and which are capable of stimulating different types of systems. The configuration of one TIS is described through the use of Test Description and Test Composition information for each SSA. A System ID is used to reference various records describing scenarios and formats. This convention allows for the independent naming of entities relating to a new system and provides multiple system support.

6. Use of the International Standards Organization Open System Interconnect Reference Model.

a. It is apparent that support of such widely diverse systems with a single TIS requires a well-coordinated design philosophy. It is necessary, therefore, to establish a common base for comparison of tactical communication protocols. The ISO reference model's layered concept of a communications protocol provides this basis.

b. Communication with each system requires some rudimentary communication protocol interface. In the TIS, this type of protocol handling is performed in the SSA. The SSA is the part of the TIS real-time software that performs highly specialized functions requiring re-implementation from SUT-to-SUT.

c. Layers 1, 2, and 3 of the ISO model are necessary for any message exchange to occur. These layers are mandatory for minimal SSA implementation. Layer 4 is a bridge between the essential lower three layers and the system-tailored upper three layers. Layer 4 assures end-to-end message transfer and provides logical (named) rather than physical (hard-wired) addressing of nodes. It is highly desirable to implement the layer 4 function in an SSA. This allows logical node addressing on the message-generation level. Processes representing layers 5, 6, and 7 are not essential to message exchange. Omission of processes representing layers 5 to 7 may cause error conditions or

illogical event sequences. Simulation of the sequences of events in layers 5 to 7 in a tactical protocol may be accomplished by careful scripting.

d. Table I shows how tactical system processes may be mapped to the layers of the ISO OSI model. This process aids in identifying SSA requirements and in designing scenarios. Figure C-1 illustrates the application of the model to the TIS functions.

Table I. MCS and TACFIRE Processes Mapped to ISO Model

MCS	ISO MODEL	TACFIRE
	Layer 7	Tactical Event Simulation
Message Format Definition	Application Layer	Message Format Definition
	Layer 6	SYS;FORM Format Skeleton Transmission
Abridging of Messages	Presentation Layer	Message Compaction
	Layer 5	Serialization, Validation
Remote Requests (filing, deletion, retrieval)	Transport Layer	
	Layer 4	Message of Interest Routing
End-to-End Accountability	Transport Layer	Remote Loop Test
Routing/Relay	Layer 3	
Autodial	Network Layer	Subscriber Table
EDC/TDC/Double Blocking	Layer 2	EDC/TDC
ACK/AUTORETRY	Data Link Layer	ACK/NAK/AUTORETRY
FSK 4-Wire 600, 1200 Baud	Layer 1	FSK 4-Wire 600, 1200 Baud
Conditioned Diphase 8K, 16K, 32K Baud	Physical Layer	55-Wire Parallel Interface

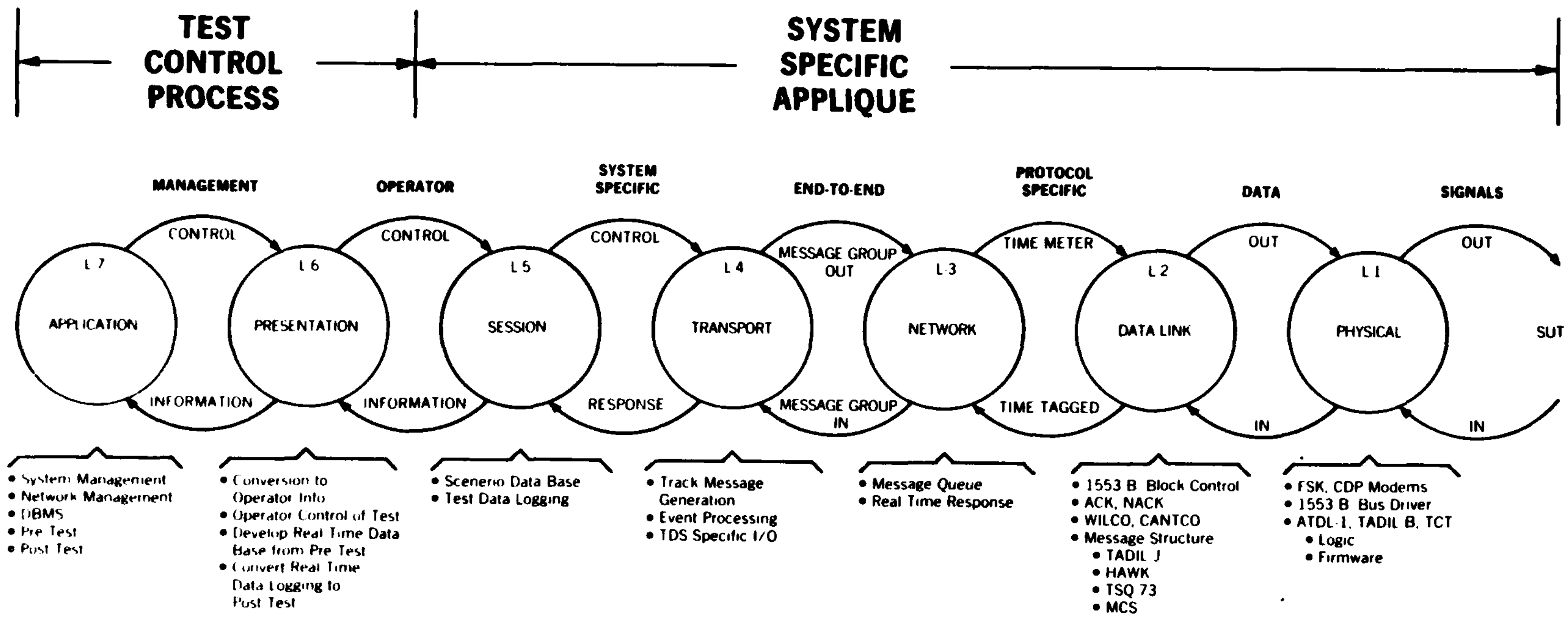

Figure C-1. ISO Model Data Flow Diagram

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